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ABSTRACT

This essay--an example of narrative inquiry--draws on a fictional account of Merlyn the Magician acting as tutor to young King Arthur to illuminate the author's own experiences as a student and teacher. Those experiences are starkly contrasted in method and intent. On the one hand, stern Mr. Thompson with his white lab coat, map of the leaf, and pointer taught objectivity along with photosynthesis in seventh-grade science lab. In contrast, Sunship Earth, a wildly creative outdoor education program, used fantasy and role playing to immerse fifth-graders in the concepts of photosynthesis as part of an ecologically based program structured on a holistic, deep connection with the earth and nature. Yet in the end, the reconstruction of the educational values in these two dramatically different modes of instruction reveals that multiple views are part of the world, to be accepted, even embraced. There are many ways to learn; the differences should not be unwelcome. Many unanswered questions persist about the magical process of photosynthesis, and only the magic of imagination prevails. (TD)

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Chapter 12

SCIENCE AND MAGIC: A LESSON IN PHOTOSYNTHESIS

gary william rasberry

Gary william rasberry is a doctoral student at the Centre for the Study of Curriculum and Instruction, University of British of Columbia. As a poet and pedagogue, he is particularly interested in the ways that we use words to write our Selves into being. In a past life, he worked as an earth educator helping people to live more lightly on the earth. (Gary can still describe and define stomata and guard cells if someone points to them on a Giant Leaf.)

In this chapter, gary gives a beautiful example of narrative enquiry at work. He draws on a fictional account of Merlyn the Magician acting as tutor to the young King Arthur to illuminate his own experiences as a student and teacher. Those experiences are starkly contrasted in method and intent, yet in the end, even as gary reconstructs the educational values in two dramatically different modes of instruction, he finds that many unanswered questions persist and only the magic of imagination prevails.

To learn. That is the only thing that never fails.

Merlyn the Magician

RC 020689

From Grad School to Grade School: Falling (Backwards) into Adventure

Lately, my life has been reduced to the blue phosphor glow of the word processor on the final drive to finishing a graduate degree. Complete with mountains of citations, an endless series of revisions, too much coffee, and not enough sleep, the academic life has begun to weigh heavily. I'm in need of a good distraction, a reasonable reason for further procrastination. My sock drawers are already organized, my books and records are arranged in alphabetical order, and the cat's nails are clipped. It's pouring rain, so any kind of outdoor exercise is out of the question. With no particular place to go, I unplug myself from the mainframe and wander down to the basement.

Before long, I'm opening old boxes filled with *Hot Wheels* and hockey sweaters, along with other long forgotten parts of my past. I fall into a box of school memorabilia and find Mr. Thompson buried in a pile of report cards and red ribbons, photographs, boy scout badges, and abandoned art projects. Mr. Thompson's name is printed clearly on the front page of a well-worn document. The lab report is organized and tidy, the handwriting foreign and familiar; I open the assignment to a complex and amateurish drawing of a leaf, carefully coloured and labelled (I must have used every pencil crayon I owned that year in Grade Seven). As if by magic, I find myself drifting back to another, almost forgotten part of my young academic life. (Cleaning the basement is fun.)

A Lesson in Photosynthesis: The Mr. Thompson Story

Is it my imagination or is Mr. Thompson staring straight at me? He doesn't say anything so I guess it was just a false alarm. Still, I feel my face flush, and the lab stool I'm sitting on suddenly feels hard and uncomfortable. This room feels different from all the others. From where I'm sitting—in the back row closest to the door—I can see rows of smooth, black counter tops that run in sharp lines across the classroom. Most of us have our own sinks,

complete with hot and cold running water. Strange valves and nozzles stick out at odd angles. Chromed and shiny, they remind me of science fiction stories I've read. (We've been warned not to touch the orange valves.)

The room is very wide from side to side, which somehow makes our teacher seem larger than life. The class goes silent and all eyes are on Mr. Thompson. Grade Seven science is serious business and Mr. Thompson, with his trademark crew cut and white lab coat, believes in a no-nonsense approach to revealing the systematic truths of science.

"All right, class, open your notebooks and copy this note on photosynthesis from the board. Make sure you leave room on the opposite page for a schematic diagram of the leaf which you will be responsible for drawing and fully labelling."

The chalkboard swims with terms, some of them underlined in red squiggly lines to emphasize their importance. I feel overwhelmed and thrilled at the same time. Everything seems so important and scientific. Mr. Thompson is bent on making sure we will remember mitochondria, guard cells, stomata, and chlorophyll for the rest of our lives. The note on the board we are all busy copying down disappears momentarily as Mr. Thompson, using his wooden pointer with the hook on the end, pulls down a large, colourful diagram of the leaf; it's on one of those strange roll-ups that hang on metal clips above the chalkboard. I've seen maps before, but seeing this huge leaf with billions of colourful parts really catches me off guard. I wonder if anyone else is as surprised as me? Mr. Thompson has a look of victory on his face; it's not a smile really, more like a twisted grin.

"I expect each and every one of you to know the names of all the working parts of the leaf as they relate to the process of photosynthesis. As I mentioned, you will be completing your own schematic of the leaf and it should appear exactly as it does here, accurately labelled and coloured."

A slight ripple breaks out and turns into a wave as it moves across the sea of heads in front of me. The "map of the leaf" fills me with an uneasy pleasure; the detail is so complex. Countless arrows lead to the many parts of the leaf. Almost every available space is taken up with long, mysterious-sounding terms. I'm drawn to the

mystery but afraid I'll never be able to make my leaf look like something Mr. Thompson would approve of.

"You will need to know this information in order to perform the class experiment next week. If you have read ahead, you will already know that we will be covering leaves with foil, to see what occurs in the absence of sunlight."

The snapping sound of the amazing leaf being rolled back up into its resting place signals the end of science class. There is a sudden frenzy of activity as thirty Grade Seven students scramble for the door. Phys. Ed. is Period Six and photosynthesis is quickly left behind.

The steady rain outside remains the only constant as I continue to rifle through the rest of the contents of the box. Everything else is up for grabs. My life is a swirl of memories, facts and fictions. Forgotten and invented. There's no turning back. Pandora's box has already been opened and I'm in no position to close the lid and slip back upstairs to the safety of grad school. Grade School is only a skip away and I'm left to wander the halls waiting for the recess bell to ring.

As it turns out, the particular memories uncovered on this most recent basement excavation are stubborn and not entirely user-friendly. The neatly labelled leaf draws me into a remembered world, parts of which I am quite happy to have forgotten. Sure, I made it through Grade Seven science. I'm holding concrete proof: Mr. Thompson approved of my lab report (and my leaf). But there's something more to my dis-ease than Mr. Thompson's obsession with leaf terminology. (Cleaning the basement is tricky.)

In the Name of Science: Learning to be Objective

In my basement explorations, I've stumbled on to something, tripped over a big word. Objectivity. Yes, I think I learned how to be objective in Mr. Thompson's science class. Mr. Thompson was a strict and serious man—the first teacher I ever had who insisted on wearing a white lab coat to class. He believed in discipline and hard work. I'm thankful for the many work habits Mr. Thompson helped me establish. The lessons learned in his class still serve me well.

Now, however, I reflect back on some of those schooling experiences with a certain amount of resentment as I recall being told that any use of personal pronouns was unacceptable. It seemed an innocent game back then: I was trained to write in a style that avoided the use of "I" or "me" or "my" as I prepared reports and observations for science class. I can't recall how strange this procedure must have felt initially—trying to make my reports appear as though I weren't there. I have clearer memories of high school, from science as well as from many other subjects, where the challenge was to make my work appear more official, more academic, more acceptable by my teachers. I suppose somewhere along the line I stopped thinking about "The case of the Missing I's." In fact, I learned how to surgically remove any and all first-person pronouns with clinical efficiency.

For me, the more serious repercussion of losing my "I's" was a gradual loss of identity. I came to believe there was a mysterious and powerful force that possessed the right answers, a force that declared itself in the name of objectivity. As long as I aligned myself with The Force, I was safe. I hid behind the "Royal We" and stayed there for almost two decades.

I suppose I can't hold Mr. Thompson entirely responsible for my apprenticeship in objectivity; he just happened to represent the first exposure to the Pronoun Police I can remember. The process likely started much earlier and then became formalized and ritualized as I progressed through high school, and eventually completed an undergraduate degree in science. (Cleaning the basement is hard work.)

I came down here for a break from school and now I feel like I'm serving a detention. Enough. I should have gone for a run in the rain. But, if Mr. Thompson can be uncovered, I'm sure he can just as easily be buried again. I shove the report (I got a B+) back in the box. I'm just about to close the lid when I find something else that looks promising (and a lot safer than photosynthesis). It's an old copy of *The Sword and the Stone*. (Forget cleaning the basement.)

The Wart's Lessons: Magical Learning Adventures

Like Alice in Wonderland on an extracurricular field trip, I wander down the hall from Mr. Thompson's science class and into the castle where the Wart is soon to become King Arthur. The Wart is a likable boy who moves through childhood under the tutelage of Merlyn the Magician. Like many boys his age, the Wart has a spirited zest for life, and for learning. He is playful and adventurous, two admirable traits that help him on his journey seeking knowledge and truth. At the same time, the Wart possesses a healthy skepticism when it comes to classrooms and formal lessons and lectures.

> "Shall we go out?" asked Merlyn. "I think it is about time we began our lessons."
>
> The Wart's heart sank at this . . . "If only," thought the Wart, "I did not have to go into a stuffy classroom, but could take off my clothes and swim in the moat . . . I wish I was a fish," said the Wart . . . The Wart found he had no clothes on. He found that he had tumbled off the draw-bridge, landing with a smack on his side in the water. He found that the moat and the bridge had grown hundreds of times bigger. He knew that he was turning into a fish. "Oh, Merlyn," cried the Wart. "Please come too."
>
> "Just this once," said a large and solemn tench beside his ear, "I will come. But in the future you will have to go by yourself. Education is experience, and the essence of experience is self-reliance." (White, 1938, p. 52)

It becomes clear in the story that the Wart is well aware of the importance of getting himself a proper "eddication" (to use the word of his foster father). It is also evident that he has quickly learned to distinguish his own natural desire to learn and grow from his reluctant acceptance of being schooled. It isn't that the Wart is a difficult student; on the contrary, he is a good kid. (Just like I was in school.) He is motivated and eager to learn new things. It seems, however, that the lessons the Wart wants most to learn occur in life, not in the classroom.

The Wart's education is entrusted to Merlyn, a wise old wizard, who has most likely won numerous Teacher-of-the-Year Awards throughout his illustrious career. Despite his noted ability, however, the familiar situation still occurs in which Merlyn's credentials as an educator are inspected and questioned by a concerned parent. In the scene that follows, the Wart excitedly introduces his foster father to the man he hopes will become his new teacher.

> "Oh sir," said the Wart. "I have been on that Quest you said for a tutor, and I have found him. Please, he is this gentleman here, and he is called Merlyn."
>
> [The Wart's guardian, wanting him to have only the best of "eddication," then responds] "Ought to have some testimonials you know," said Sir Ector doubtfully. "It's usual."
>
> "Testimonials," said Merlyn, holding out his hand. Instantly there were some heavy tablets in it, signed by Aristotle, a parchment signed by Hecate, and some typewritten duplicates signed by the Master of Trinity. (White, 1938, p. 45)

To witness the questioning of Merlyn's reputation, despite his impressive list of credentials, brings humour to my often insecure musings over whether or not I will ever be well enough qualified to teach. (Despite the fact that I have been teaching now for over ten years.) I also see it as quite a wonderful feat for a student to be able to choose his or her own teacher. As luck would have it, the Wart and Merlyn are united and set out on a journey of magical learning adventures. Together, they are able to forge their own brand of education and transcend the limiting and narrow view that often separates life and learning. As well as becoming a fish to explore the mysteries of the underwater world, the Wart also turns into an owl to discover the beauty of flight, and a snake to learn the ancient stories and legends. He sets out on adventures that lead to a meeting with Robin Hood to learn of bravery, humility, and courage. He also visits a goddess and is presented with "The Dream of the Trees" and "The Dream of the Stones" in order to experience the wonder and awe of Creation.

These powerful field trips the Wart experiences as part of his schooling could hardly be considered extracurricular. Of course,

the Wart also reads and writes and learns his Latin, along with all of his other lessons. The love and respect for learning that he and Merlyn share is indeed powerful.

> "The best thing for disturbances of the spirit," replied Merlyn, beginning to puff and blow, "is to learn. That is the only thing that never fails. You may grow old and trembling in your anatomies, you may lie awake at night listening to the disorder of your veins, you may miss your only love and lose your moneys to a monster, you may see the world about you devastated by evil lunatics, or know your honour trampled in the sewers of baser minds. There is the only thing for it then—to learn. Learn why the world wags and what wags it. That is the only thing which the poor mind can never exhaust, never alienate, never be tortured by, never fear or distrust, and never dream of regretting. Learning is the thing for you." (White, 1938, p. 254)

The story (the Wart's as well as my own) gets more complicated as it progresses. The plots thicken, yet already I seem to have strayed too far from chlorophyll and the production of carbohydrates by green plants. I bade farewell to Mr. Thompson at the end of Grade Seven (I moved to a new school). Life (and learning) continued and I succeeded through a series of parent-pleasing graduation ceremonies. Eventually, I found my way back to the world of white lab coats as an undergraduate science student in university.

The time came for the Wart to move on as well. He grew up and matured, and his lessons with Merlyn came to a close. Eventually, he "graduated" and moved on to the next phase of his life. Unlike my uneventful parting with Mr. Thompson, the Wart is deeply saddened by the knowledge that Merlyn will no longer be his teacher and companion in learning. He turns to other realities which he must now face and laments the fact that the adventures and joys he experienced as Merlyn's student were almost too good to be true. He feels that somehow he must now accept whatever new fate befalls him as a result of his privileged past.

> "Well, I am a Cinderella now," he said to himself. "Even if I had the best of it for some mysterious reason up to the present time in our education, now I must pay for all my past pleasures and for seeing all those delightful dragons, witches, unicorns, cameleopards and

> such like . . . Never mind, I have had a good time while it lasted, and it is not such bad fun being a Cinderella, when you can do it in a kitchen which has a fire-place big enough to roast an ox." (White, 1938, p. 249)

The Wart experiences his convocation as though it were a trial. He awaits the next phase of his education as one awaits a verdict to be handed down. He appears quite willing to give up his innocence, as though there are no other possibilities.

Education, at least for the Wart and me, seemed to be a process that became progressively more serious and more difficult; the sooner we accepted this notion, the better. Maybe that's why I found Mr. Thompson's class so threatening. Science became something that took place only in a science room—and in my Grade Seven experience—by someone who wore a lab coat, by someone who was stern and serious. Gone were the days when we went out to the field beyond the schoolyard for science class. In Grade Seven, I learned to perform a series of scientific manoeuvres according to a newer and stricter set of rules.

How is it we learn to be like the Wart? What causes us to assume that our education must be painful in order to be satisfactory? When do we begin to dismiss the fun things as distractions to real education, taking part in them only with a certain amount of guilt, as well as an unspoken understanding that we will pay for our pleasure later? Where do we get the notion that it is important to grow up and out of our past experiences, instead of learning to use them as springboards to new experiences or as safety nets to fall back on when needed?

All these questions from just one box. I'm beginning to understand why the Wart's story has surfaced. There are many more questions to be asked, and many more lessons to be learned. It's likely not a coincidence that the Wart and Merlyn and Mr. Thompson share the same box. Discipline and seriousness are the backdrop to the Mr. Thompson story; adventure and magic are the elements in the Wart's story. The fact that the two stories seem so different from one another is also what draws them together as I begin to story and re-story my educational experiences. I can't imagine Mr. Thompson as the Wart's tutor, just as I find it difficult to imagine Merlyn as my Grade Seven science teacher. There is,

however, much to be gained from imagining some of the possibilities that might stem from a marriage of plot and character in both of these two stories. How would Merlyn have taught photosynthesis? With some pomp and ceremony, Merlyn decreed, "The best thing for disturbances of the spirit is to learn—to learn why the world wags and what wags it." What would Mr. Thompson's famous speech on learning have been? How would the Wart have handled sitting on one of those hard and uncomfortable stools in Mr. Thompson's science room? How would I have reacted to becoming an owl to learn about flight? I carry these questions with me as I continue to reflect on experiences that have influenced my learning and, in turn, my teaching.

The Adventures of Teaching: Life at the Outdoor School

My first teaching job was far from the classroom. I became an environmental resource teacher, and, eventually, the program director of a large, outdoor education centre. We offered week-long residential programs to school groups that ranged in size from sixty to one hundred and thirty students per week. We worked closely with a group called the Institute for Earth Education (Van Matre, 1990). They were a nonprofit organization which designed and disseminated specialized, ecologically based programs structured on a holistic, deep connection with the earth and its life. Our centre, in conjunction with our affiliated school board, became heavily involved in piloting Earth Education programs designed to help people of all ages live more harmoniously and joyously with the natural world. A decision was made to implement *Sunship Earth*, an intensive residential program designed for twelve- and thirteen-year-olds (Van Matre, 1979).

The name *Sunship Earth* came from Buckminster Fuller's notion of the earth as a self-contained vessel travelling through space, a spaceship powered by the energy of the sun. The goals of the program included providing an understanding of how the planet functions in an ecological sense, nurturing deep feelings for the natural world and all its life, and crafting a lifestyle more harmonious with the earth and all its passengers (Van Matre, 1990). All of this took

place against a wild and wonderful backdrop of creativity. The kids literally lived the program as they became passengers aboard our Sunship Earth in order to better understand its delicate operating principles. It was a carefully crafted program: every activity—every detail—focused on our roles as passengers and crew aboard the Sunship. Every facet of the program supported the original goals of providing better understandings, nurturing feelings and developing a lifestyle more in tune with the earth and its life. Our invitation to the students was, "Hey, we're on a sunship! How does it work and feel? We're both its passengers and its crew. What does this mean for you?" (Van Matre, 1979, p. 36). Much attention was given to even the most minute detail in order to capture the fancy and the imagination of the kids and teachers, and to make the learning of abstract ecological concepts more concrete for the learners.

All of the program's objectives translated to a wonderful and unusual learning environment. Visitors walking around the centre, unfamiliar with the Sunship Earth program, might feel as though they had stumbled upon another planet. The woods were filled with many strange sights: costumed teachers and students role-played in order to learn of the story of life on the planet. They were busy exploring "The Seven Secrets of Life," according to the formula "EC-DC-IC-A." These are the seven key operating principles—the key ecological concepts—that govern life on our Sunship: energy flow (E), the cycling of materials (C), diversity (D), community (C), the interrelationships of living things (I), change (C), and adaptation (A). The kids learned about EC-DC-IC-A on "Concept Paths" by weaving their way through the woods. There were three different concept paths, each one housing five concept stations. Kids became animals in a food chain as they visited "Mr. Sun's Restaurant" to learn about energy flow, or clouds in "The Sun's Bucket Brigade" to take part in the earth's great water cycle. They were birds in "Tools and Tasks" to experience how a beak is a tool that is specially adapted for performing certain tasks, or molecule messengers visiting the "Food Factory" to learn how sunlight is captured by green plants and turned into food. It was an impressive program to see in action.

Another Lesson in Photosynthesis: The Giant Leaf

[Somewhere in a sunlit forest . . .]

"Yeah, I think it's over this way. Who has the map anyway?"

The sun filters through the trees and splashes on to the trail in front of us as we wind our way along the forest path. A shout, "Kevin knows where we're going!" breaks through the collage of voices, all laughter and complaints and questions and commotion.

Our little group makes its way up a short, steep hill with a surprising amount of enthusiasm. I'm realizing that it's been an intense morning when my thoughts are interrupted by an imposing set of signs. "**Keep Out! Authorized Personnel Only. Top Secret.**" By now, the kids know something is up and they look to me for some kind of hint of what's to come. The students and I exchange glances —looks that say that I know that they know that I know that all of this is part truth, part fiction, part fantasy. I believe it is an unspoken bit of madness that brings us here and propels us on this magical learning adventure together.

I scan the horizon with a worried look and then begin nervously glancing to my left and to my right. The kids pick up on this action and whether they are interested in humouring me or not, respond to my unspoken urgency by gathering around in a tight little circle. I motion with my eyes to a sign that says "Food Factory" (Van Matre, 1979) and begin to move cautiously down a narrow path that curves slowly and disappears up ahead. They don't need to be told to follow. Within thirty seconds we round a bend that takes us in between a set of imposing pines, and Chris spots a large cave-like structure with a low, rounded profile. It is covered in green canvas and camouflage and has a tube-like tunnel for an entrance.

"What the heck is it?"

"Only the most important thing on our planet," I say in a lowered voice. "It's a giant leaf. A food factory."

What do my eyes tell them? Still using my top-secret voice, I let them know that we're going to get the inside story on how we get our energy from the sun.

"You are all going to get a chance to go inside the food factory to find out how sunlight energy is turned into sugars, or carbohydrates, the food that we need to stay alive; the problem is that no

one really knows exactly how it's done. This is a very important mission and you must all swear to secrecy."

"It's not really a leaf, I can see the canvas."

Ah yes, it's James again, stating the obvious. He's been making sure the group doesn't get fooled by any of this becoming-a-cloud or going-into-a-giant-leaf stuff. After we finish our secret oath, I explain that only half the group can go inside the leaf at one time, and that possibly James could lead the first mission.

"While the first group is inside the leaf, the rest of you have an important job. You are going to be 'Molecule Messengers.' You'll deliver the ingredients that the leaf needs to work its magic."

We walk over to an area looking like a bus stop with a sign that reads Molecule Messenger Waiting Area. I pull out three pouches labelled "AIR," "WATER," and "SUNLIGHT."

"The group inside the leaf will be communicating with the 'Chlorophyll Control Centre' and will be asking for these ingredients. When you messengers hear someone call for an ingredient, run over to the leaf with the correct pouch and hand in one of the envelopes from inside the pouch. Then return immediately to the Messenger Waiting Area."

"So what are we supposed to do in the leaf anyhow?"

That's Ian. His self-proclaimed title is junior executive in charge of role clarification and job descriptions. He wants to make sure everyone in the group knows exactly what is expected of them at all times. I give him the over-the-shoulder glance along with an accompanying shifty-eyed stare. He drifts a little closer, understanding that this is privileged information. The rest of the group eavesdrops.

"Listen," I explain, "I haven't actually been inside the leaf myself. What I've told you so far is what everyone knows about the food factory. Scientists know what goes into the leaf and they know what comes out of the leaf, but nobody actually knows exactly what goes on inside the leaf itself. Carbon dioxide and water go in and sunlight is around, too; then, after a while, sugars are produced and, eventually, we eat them in some form or other. But what happens inside the leaf is the real mystery—that's why you're being sent in there: to find out how the mysterious process of photosynthesis works."

In a slightly quieter voice, I tell them that they are going to be "chlorospies." "You'll need these green helmets to help camouflage you so that you are better able to spy on the chlorophyll."

A barrage of comments breaks the silence of the forest.

"I'm not wearing this stupid helmet, it'll wreck my hair."

"Cool; it looks dark in there."

"I'm going first!"

"When's lunch?"

"Like I said, I won't be going inside the leaf myself since I don't have the proper clearance, so you're on your own. The messengers will be passing the carbon dioxide molecules and the sunlight in the envelopes through the walls of the leaf. Water will also enter in the same way it does in a real food factory—up through the stem. Remember, only the chlorospies have security clearance so the messengers will have to wait outside. You'll receive further instructions once you are inside the factory. Good luck, everybody."

The first group of chlorospies disappear into the leaf. Things seem to be running smoothly. I wasn't being quite truthful about not having been inside the leaf myself. I have security clearance in the off-hours and, in fact, I know exactly what they'll find in there. I can picture it now as I stand quietly with the molecule messengers at the waiting area. Julia was right, it is dark in there, and as their eyes adjust, they will be greeted by a number of signs. One sign reminds them of their pledge to secrecy while another identifies a large green box with a slot in the top as the "Super Secret Chlorophyll Box." Another sign simply says, "Await Further Instructions." The three of them will have just about checked the whole place out, when a voice will speak to them from a tube lying on the floor.

"Attention. Attention. Can you hear me? This is Chlorophyll Control."

I always take pleasure imagining the look on their faces when this voice comes resonating through the leaf. The speaking tube leads out of the back of the leaf and runs unobtrusively into the woods where a volunteer parent is hiding behind some bushes a short distance away. The voice begins.

"Thanks for coming to work on the production line at the food factory. You will have to follow my instructions carefully, OK?

Now, here in the food factory we need some important ingredients in order to make food-energy, or carbohydrates. Together, call to the molecule messengers for the first important ingredient, AIR. Ready? One, two, three: AIR!!!"

I'm snapped out of my little daydream by a sudden scrambling of molecule messengers. The AIR messenger sprints off to the leaf, delivers his package, an envelope containing two ping-pong balls —one marked carbon and one marked oxygen—attached together by velcro. Things should begin to "cook" in the leaf right about now.

"Tell me when you've got it," the Control Centre voice drones. "What do you find in the envelope? [pause for the kids' response] That's carbon dioxide—C for carbon, O_2 for oxygen. At the food factory we get our carbon dioxide directly from the air."

"OK, call for the second important ingredient, WATER. . . . Got it? Great. What's in the envelope? [pause] That's hydrogen, H_2, and oxygen, O, the parts that make up water. Now listen very carefully. Pull off the carbon, C, from the carbon dioxide and pull off the hydrogen, H_2, from the water. Try to stick the carbon, the hydrogen, and the single oxygen ball together to make a carbohydrate, the food energy for all life. The three balls should all stick together like links in a chain. How are you doing?"

By now the water and the air messengers have done their job and we're all standing around chatting.

"When do I get to go?" Gail is the SUNLIGHT messenger and she is not too happy about not being called.

"I'm not sure," I reply calmly. "Let's just wait a bit longer, something definitely seems to be going on in there."

"What's wrong?" Chlorophyll Control asks, sounding somewhat alarmed. "You have the hydrogen and oxygen stuck together, but the carbon won't stick to the hydrogen?"

I can't really tell Gail that I do know exactly what's going on inside the leaf. They are trying to fit a round peg into a square hole right about now. That is, the placement of the velcro strips on the ping-pong balls (I mean molecules) is such that it is impossible to attach the carbon molecule to the hydrogen molecule no matter what mark you got on your last science test. (I'm not worried though; nature will provide the solution.)

"This is impossible!"

"How do they expect us to do this?" Julia and Nicole cry foul.

"Something must be missing." The Chlorophyll Control speaks with the voice of reason. "OK then, call for SUNLIGHT. Now, using the sunlight, try to stick the carbon and hydrogen together. Got it? Congratulations! You've just completed the process known as photosynthesis. That's the process that takes water, air, and sunlight and makes energy-rich food for all life. Just put your completed carbohydrate into the box and your work shift is over. Oops—there's one last thing you need to do. Push your leftover oxygen (O_2) out the 'Oxygen Exit Tube.' Well, thanks for helping out on the production line here at the Food Factory. You can go out now. This is Chlorophyll Control Centre signing off."

Julia, Nicole, and Brian emerge with shielded eyes from the giant leaf; they look like celebrities who have just finished a press conference. I recognize my own voice asking the first question.

"Well, what happened—did you find out the secret?" I'm drowned out by other urgent queries.

"How hot is it in there?"

"Where's the sugar?"

"What took you so long?"

"We couldn't bring the sugar out because we had to leave it in this special top-secret box, and yeah, it was boiling in there," says Brian.

A little disappointed at not getting the information I was hoping for, I suggest the Molecule Messengers switch roles with the Chlorospies and we try the whole thing again.

The students add their newly acquired information about the concept of energy flow to their passports. They also draw and describe other examples that exist around us here in the forest.

At the end of it all, the elusive inner workings of photosynthesis still remain a secret. It seems that photosynthesis really is part mystery and may remain so for quite some time, despite determined efforts on our part. "I guess we shouldn't feel badly," I tell them. "Even the most brilliant women and men in science don't know exactly how the process works." (Not even Mr. Thompson, I'm thinking to myself.)

Nothing Up My Sleeve: A Closer Look at Magic

It's difficult, though not entirely impossible, to envision Mr. Thompson as a molecule messenger. Some of the Sunship Earth activities might have ruffled his white lab coat, but I don't think he would have disagreed with the educational objectives of this particular Earth Education program.

> What sort of frame or goals did we have in mind? First, like a surveyor, we wanted to cast a point of reference for each of our learners—to convey something about their place in the universe. We hoped to establish this sense of place forever in their understandings, or perhaps more accurately in their feelings, for we wanted it to become embedded inside them, where it would be a continued source of awareness about who and what they were. Second, like a friendly wizard, we wanted to convey to them a feeling for life's wondrous mysteries—the awesome, yet joyous, systems in which they are bound up with every other living thing on earth. And we hoped that this recognition of miraculous interrelationship would become a mental touchstone against which they could forever check their actions. (Van Matre, 1979, p. xvi)

I have been quick to point to Mr. Thompson's (lack of) magic in conveying the wondrous mysteries of life on our planet. I have been just as quick to align myself pedagogically with Merlyn: a "friendly wizard [conveying to his students] a feeling for life's wondrous mysteries—the awesome, yet joyous, systems in which they are bound up with every other living thing on earth" (Van Matre, 1979, p. xvi). Like the Wart, I would have preferred to become a fish rather than to dissect one. But magic, as it turns out, is not all that it's cracked up to be. As an educator, committed to connecting understandings with feelings, I stumbled and (eventually) tripped over magic on more than one occasion. I now wonder whether my pursuit of magic wasn't also a kind of reactionary running-away from Mr. Thompson.

After enjoying much success with programs like Sunship Earth and discovering the delights of teaching and learning as though they were part of an adventure, like Wart, I wondered, "Must I now pay for all my past pleasures?" For teaching all those weird and wonderful activities. For becoming a squirrel to find out how

animals must solve problems and adapt to find food. For becoming a cloud in order to take part in the earth's great water cycle. For going inside a giant leaf to discover the mystery of photosynthesis. For roaming through the dangerous forests of King Snoyd's kingdom to find out about the interrelationships of living things. For shrinking down to the size of a bug to explore the world from a new perspective.

Surely these activities were kid's stuff, right? It was a lot of fun doing all those crazy things, but that's not how real learning takes place. Is it? The Sunship Earth program was just a diversion from regular school. Wasn't it? I got to be outside—to explore and adventure with kids. Together we learned the story of how life works on our planet. So why did I feel like the Wart at the end of it all—waiting to "graduate" to more serious learning? What went wrong?

Was I trying too hard to wear Merlyn's cloak? I wanted the kids to have experiences like those of the Wart's, but in fact I am not a magician. Creating magical learning adventures is hard work. It involves paying close attention to every detail. Perhaps part of the illusory quality of magic is that things appear—as if by magic—with the wave of a wand. Closer scrutiny, however, usually reveals the detail, the precision—careful and calculated—required to make the magic. (In the end, Dorothy meets the man behind the curtain who doesn't seem like much of a wizard at all.)

I don't mean to strip away the magic by looking at it too closely. I am simply aware that creating a giant leaf for a group of kids to stumble upon, as if by accident—as if by magic—out there in the forest in order to learn the intricacies of photosynthesis requires a great deal of work. So do Mr. Thompson's carefully crafted lesson plans. The giant leaf, it seems, requires a cautionary note similar to the one given Mr. Thompson's science lab: "Don't touch the orange valves and don't forget to close the door to the leaf on your way out."

Is the magic of the Food Factory misleading? Does the translation from molecules to velcroed ping-pong balls clarify or confuse conceptual understanding? Is the trip inside the leaf an invitation to, or a distortion of, further learning? Is learning lost in the excitement of the molecule messenger-to-chlorospy exchange? Can a process

as complex as photosynthesis be simplified to a disembodied voice (Chlorophyll Control Centre) providing a set of instructions to a handful of kids huddled in the dark? Yes? No? Maybe? Sort of? It depends? Why? Why not?

Surely Mr. Thompson's plasticized map of the leaf is also a distortion—torn from a tree and left to flap above the chalkboard in a series of unnatural colours. My capacity to memorize the various parts of the leaf and the countless terms involved in photosynthesis did little to convey the wonder of such a process. Isn't Mr. Thompson simply another (disembodied) voice providing a set of instructions to a handful of kids huddled (in the dark) behind desks?

The answers will not be pinned down like parts of a frog in this particular reflection. I feel like Calvin (of Calvin and Hobbes fame), who, in one particular episode, begins to experience life from a "neo-cubist perspective." Sparked by a debate with his father, Calvin begins to see both sides of everything; multiple views provide too much information; chaos rules as his world fractures into unrecognizable fragments. Calvin resolves the problem quickly, as only Calvin can, then turns to his father and says, "You're still wrong, Dad."

Mr. Thompson Meets the Giant Leaf: The Many Faces of Photosynthesis

Although I admire Calvin's style, my task does not seem quite as simple. At the same time, I am not necessarily attempting to resolve anything, or prove anyone wrong. Multiple views are part of my (chaotic) world; I try to accept them, even embrace them.

There are a lot of ways to learn about photosynthesis. My experiences with the process, as a student and eventually as a teacher, certainly represent two very different possibilities; in hindsight, these differences don't seem at all bad. In fact, it's a luxury to be able to reflect on the unique and contrasting approaches to the teaching and learning of such a magical process.

In my schooling, I happened to first learn about photosynthesis from the confines of Mr. Thompson's classroom, where sunlight was conspicuously absent from the whole process. I learned partly out of fear, partly out of fascination. I was intimidated by

Mr. Thompson's apparently cold exterior; I felt compelled to learn and memorize the multitude of facts that he presented in strict fashion. I was a good kid in school, impelled to please parents, teachers, and peers. If the assignment was to draw and memorize every part of the leaf, then I would do exactly that. Yet, I was also intrigued by the large and mysterious schematic diagram of the leaf with its complex circuitry. Maybe the plastic roll-down chart was simply another kind of magical giant leaf.

I must also admit that there was something compelling about Mr. Thompson's style. Perhaps it was his white lab coat and his pointer. Or maybe it was how serious and scientific he made everything seem. He was the living image of the scientific method—an impressive and striking model for a kid just out of elementary school. Our class was held in a real science room—a special place designated for experiments of all kinds; it was filled with glass display cases that contained beakers and test tubes and all manner of laboratory supplies.

With Mr. Thompson, science (and photosynthesis) seemed impressive and official; he brought the scientific method to life. Mr. Thompson helped to lay the foundation upon which the rest of my scientific inquiry in schools would be constructed. At the end of Grade Seven, I couldn't imagine photosynthesis spelled any other way.

But what would have happened if the process had been the other way around? What if I had crawled inside the giant leaf—as the Wart might have—as a chlorospy in Grade Five before arriving in Mr. Thompson's Grade Seven science class? What if I had learned about photosynthesis—the capturing of sunlight energy by green plants—by wandering and exploring in a rich, green forest where the process was taking place all around me? What if I had been introduced to photosynthesis by a person in shorts and a T-shirt instead of a white lab coat? (By someone I thought was cool, not scientific.) What if I had been able to handle the "molecules" and then push an extra oxygen molecule out of the leaf, giving me a concrete memory of green plants releasing oxygen? What would it have felt like to have been a twelve-year-old messing around inside a dark, cave-like structure, and suddenly have a voice speak to me from out of nowhere? What if?

And how would Mr. Thompson have reacted to the Giant Leaf? Would he have eagerly crawled inside? What would the map of the leaf he unveiled so impressively in the classroom have looked like to me and my classmates after having been chlorospies? Would I have been intimidated or bored? Would I have been completely turned off by the map of the leaf after having been inside one, or would I have been more curious to explore the complex parts of the leaf because of that fact? How would I have felt about Mr. Thompson's photosynthesis experiment, performed in his windowless room—in which we attempted to discover what happens to a leaf when it is covered in foil—having already walked through a sun-splashed forest to the giant leaf in Grade Five.

I'm not sure what part of my Grade Seven experience led me to want to teach photosynthesis in the way that I did. Mr. Thompson provided the pieces to the process of capturing sunlight energy without regard for the bigger picture of how life on the planet works. Maybe that came in a later unit that we never got to. I don't think so. My memories of those pieces taught to us by Mr. Thompson are sharp, like those parts of the leaf that stood out in "living" colour at the front of the room. I can incorporate the pieces into the broader picture of life I now possess, thanks to the giant leaf and the Sunship Earth program.

Of course, I'm no longer a student of Mr. Thompson. I'm a teacher—a colleague of his in a sense. We both put our efforts toward helping kids learn about science in the ways we saw fit at the time. We share much in common as a result. It would be interesting to talk shop with Mr. Thompson today—to discuss our practices, our beliefs, our thoughts on why we do what we do.

Experience into Story: Lives Remembered and (Re)invented

The narratives I have told up to this point must be taken for what they are: stories. From the dampness of my basement, I have attempted to write myself out of the box, on to the page, into existence. The word processor seems not only an appropriate tool, but also an excellent metaphor with which to help me sort out the thoughts that tumble forth looking for places to land.

Words. The signs and symbols, the codes I use to invent and reinvent myself. Words. Processed. Words. Sorted, scrubbed, sanitized, subjected to filters, both kind and harsh. Words. Remembered, forgotten, made up, manufactured, managed, make-believe. My words fall on to the page and build stories from sentences that conflict and contradict one another. Didn't I say that Mr. Thompson's white lab coat and specialized science room might have been problematic in alienating me from my own learning? (Only to wonder if they didn't also appeal to my newly forming scientific sensibility.) In writing and remembering, I am engaged in a process that is as much about self-construction as self-discovery.

I seem to have come full circle from my Grade Seven lab report. (Or have I?) Mr. Thompson wanted structure, order. Science was spelled using upper-case. I was discouraged from clouding the results with my own "I." Today, I resist the pull of order in my writing, yet my stories remain neat and tidy. If things get too messy, I can always put them back in the box, close the lid. I push against convention, interrogate Mr. Thompson's attempts to toilet-train me into objectivity. Yet, I now question my own intentions as a story-maker. Am I being too subjective? I build my life with, in, and through words. I paint stories using colours of my own choosing. My intentions are good; I strive to find sense, to make meaning of my life experiences, but the search for Truth, the life as it was really lived, is a misleading one. The life I (have) live(d) is the one I make up. I am caught up in language, in word-making, constantly striving to create the world.

I once worried about losing my identity under Mr. Thompson's resolve to remove all personal pronouns; now, I struggle over which "I" is me. Merlyn said, "To learn. That is the only thing that never fails." Currently in Grade Twenty-four, I continue to celebrate my own ways of learning and knowing. And through it all, I continue to word my world—as if by magic. Merlyn would be impressed.

This is Chlorophyll Control Signing Off: A Final Reflection

All of this reflecting has helped me to make explicit what was once buried and tacit (like the box in the basement). I discovered parts of me that emerged through my practice, of which I am both proud and embarrassed. I still wonder about Mr. Thompson. I wonder what stories he might tell about the classes he once taught. I wonder what stories my former classmates might tell. Do they even remember Mr. Thompson? Perhaps they have forgotten about the map of the leaf. Maybe photosynthesis only rings a faint bell when it appears on Jeopardy: "All right, contestants, this one for $10,000.00 . . . Answer: The production of complex organic materials from carbon dioxide, water, and inorganic salts, using sunlight as the source of energy and with the aid of chlorophyll and associated pigments. Question: What is photosynthesis?"

Personally, I don't feel cheated for not having had the opportunity to be a molecule messenger as a twelve-year-old. Like the Wart, I seem to have "had the best of it for some mysterious reason." Just over a decade after leaving Mr. Thompson's classroom, I was crawling around inside the giant leaf. I was busy making sure the molecules were in order, the instructional signs in place, and that the voice for Chlorophyll Control was out of sight and ready to go. I was out in the natural world, surrounded by living things, and by kids, and we were learning together. I'm not sure it would have fit Mr. Thompson's vision of the scientific method but it certainly was an experiment.

Perhaps in some strange way I was doing it for Mr. Thompson. Not in spite of him, but because of him. I am a product of all of my combined experiences. Whether it was Mr. Thompson's white lab coat, his pointer, his map of the leaf, his adherence to scientific principles, or whether it was crawling around inside of the giant leaf as a chlorospy, I will always think of photosynthesis as a magical process.

References

Van Matre, S. (1979). *Sunship earth: An acclimatization program for outdoor learning*. Martinsville, IN: American Camping Association.

Van Matre, S. (1990). *Earth education: A new beginning*. Warrenville, IL: The Institute for Earth Education.

White, T. H. (1938). *The sword in the stone*. London and Glasgow: Collins Clear-Type Press.